AYDIN
ADNAN MENDERES UNIVERSITY
FACULTY OF ENGINEERING
Department of Electrical and Electronics Engineering

EE441 – Programmable Logic Controller (PLC)

Prof. Dr. Yılmaz KALKAN



- Basic of Industrial Automation
- Understanding Automation & Control System
- History of PLC
- Basic Components of Automation
- Hardware / Software Classification Of Automation

outline

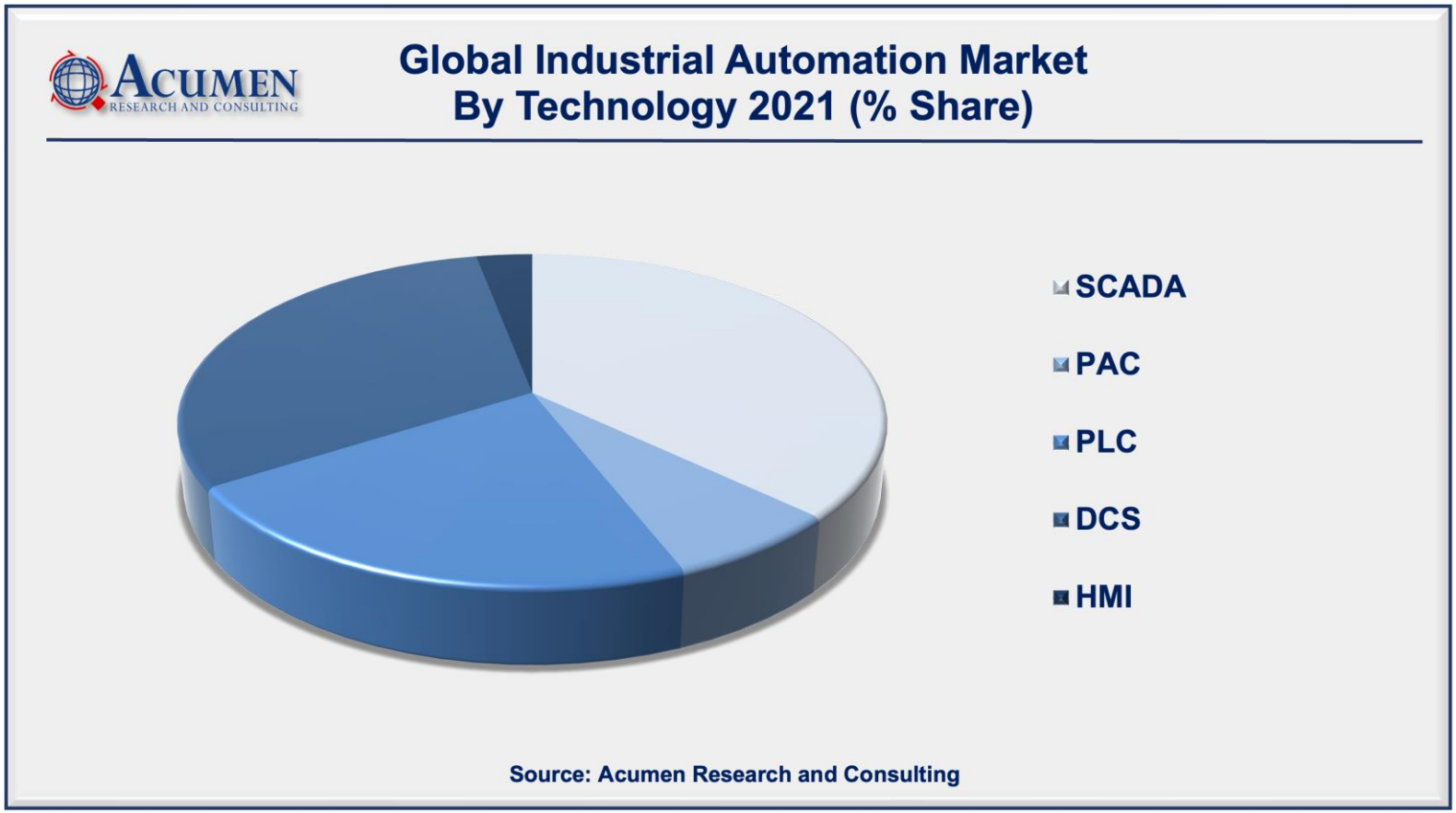
- Introduction to PLC
- Need of PLC in Designing
- Architecture of PLC
- Application and Advantage of PLC
- Automation Concept And Basic Design
- NO/ NC Concept

- PLC Programming
  - Introduction of Ladder Logic
  - Introduction of SFC
  - Introduction of Instruction list
- Creating & Editing Ladder Logic Program
- Different Types Of Sensors-Sinking, Sourcing, NPN, PNP
- PLC Fault Finding, Trouble Shooting
- Forcing I/O's
- Detailed Sequence of Wiring
- PLC Control Panel Wiring
- Interfacing With Relay Logics

Advantages of PLC – Why PLCs are around?

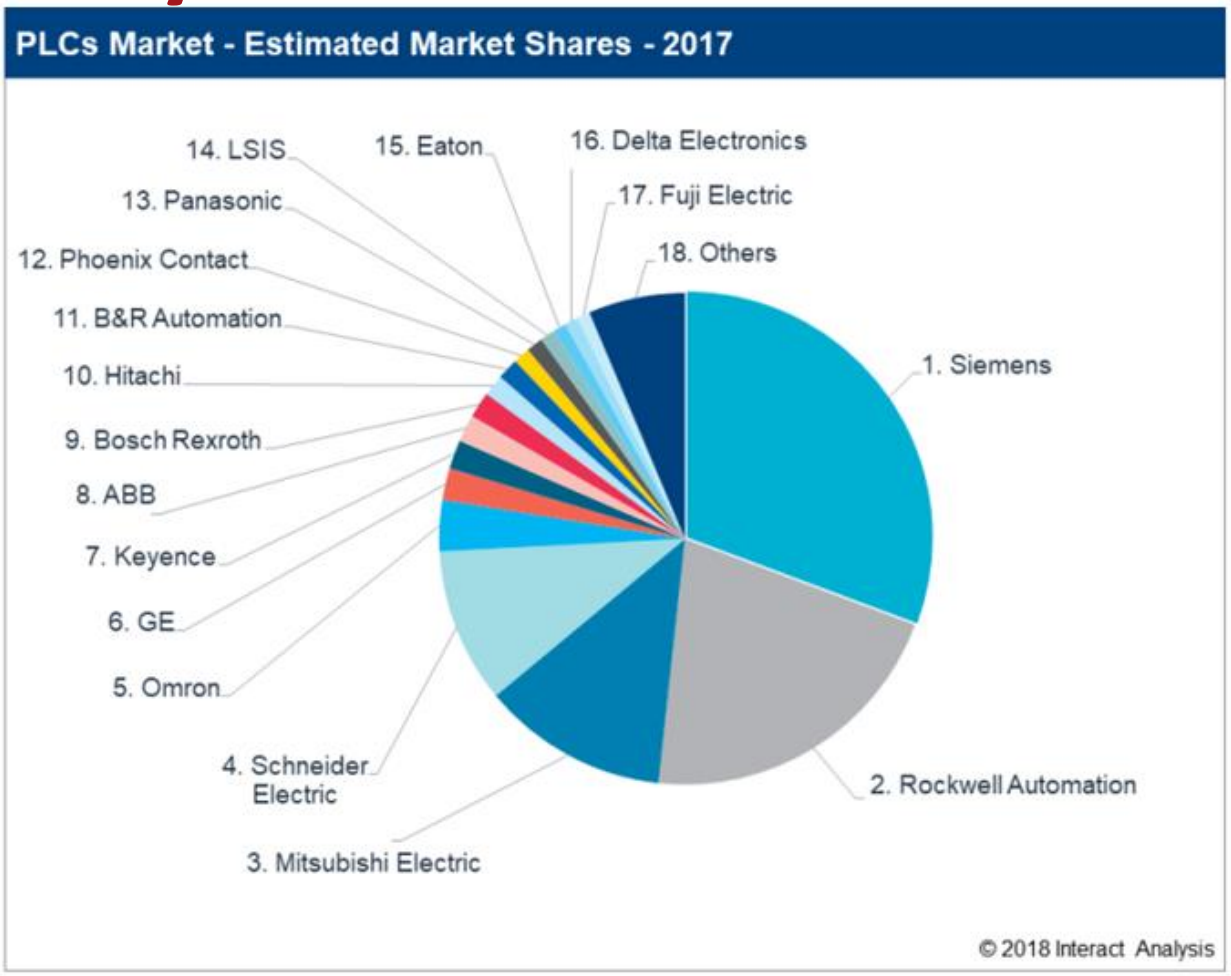
- ✓ Less wiring
- ✓ Wiring between devices and relay contacts are done in the PLC program
- ✓ Easier and faster to make changes
- ✓ Troubleshooting aids make programming easier and reduce downtime
- ✓ Reliable components make these likely to operate for years before failure

Global Industrial Automation Market



SCADA – Supervisory Control and Data Acquisition System
PAC - Programmable Automation Controller
PLC – Programmable Logic Controller
DCS - Distributed Control System

Major Players



https://www.mordorintelligence.com/industry-reports/programmable-logic-controller-plc-market

Why Mitsubishi PLCs?

- ✓ Because WE HAVE ☺ (5 sets ME PLCs were donoted)
- ✓ Mitsubishi is one of the biggest PLC Manufacturer
- ✓ Commonly used in global industry
- ✓ It is easy to use with its own language/interface
- ✓ It has simulator for education
- ✓ Its documentation is simple and extensive

Mitsubishi FA e-learning

- ✓ Mitsubishi Electric offers FA e-learning programs in 18 languages (as well as Turkish)
- ✓ https://www.mitsubishielectric.com/fa/assist/e-learning/tur.html
- ✓ All documents can be found in this site
- ✓ https://www.mitsubishielectric.com/app/fa/download/search.do?kisyu=/plcf&mode=manual

(also for manuals)

Ch2: PLC – Which PLC?

mitsubishielectric.com/fa/assist/e-learning/tur.html

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Changes for the Better
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The PC/Tablet edition requires a screen resolution of XGA (1024 x 768) or higher.
The PC edition can be downloaded by clicking on the following icon.
For further information about methods of expanding data in the PC edition, refer to "Using the PC edition data" located at the bottom of the page.

Using the PC edition data

Turkish

Courses		PC	PC/Tablet	PDF
	PLCs			

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FA Equipment for Beginners (Programmable Controllers)

This course is intended for first time users to grasp an overview and understanding of programmable controllers.

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Introduction **Course Structure**

Chapter 1 - What is "Sequence Control"?

You will learn about the basics of sequence control, including the meaning of the term "sequence".

Chapter 2 - What is a "Programmable Controller"?

You will learn about the history, structure, operation, and programs of programmable controllers.

Chapter 3 - Application Examples

You will learn about application examples of programmable controllers.

Final Test

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Chapter 1 What is "Sequence Control"?

A programmable controller, which is also referred to as a "programmable logic controller" or "PLC", is a control device used for industrial automation.

Until now, countries around the world have developed their economies by mass-producing and consuming products.
Mass production is achieved by using machinery.
The efficiency of the mass production is further increased by automating machine operations.
In this chapter, let's learn about sequence control, which is the basics of industrial automation.

1.1 Meaning of "Sequence"

1.2 Sequence Control

1.3 Application Examples of Sequence Control

1.4 Devices Required for Sequence Control

1.5 Basic Sequence Control

A control system in which the individual steps are processed in a predetermined order, progression from one sequence step to the next being dependent on defined conditions being satisfied.

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1.1 Meaning of "Sequence"

The term "sequence" refers to a succession or order in which events occur.
Accordingly, "sequence control" can be defined as the controlled operation of a machine according to a predetermined sequence.

Sequence control is widely used in our daily lives.
Vending machines and washing machines are just a couple of examples of machines that operate on the principle of sequence control.



Car-washing machines



Vending machines



Washing machines

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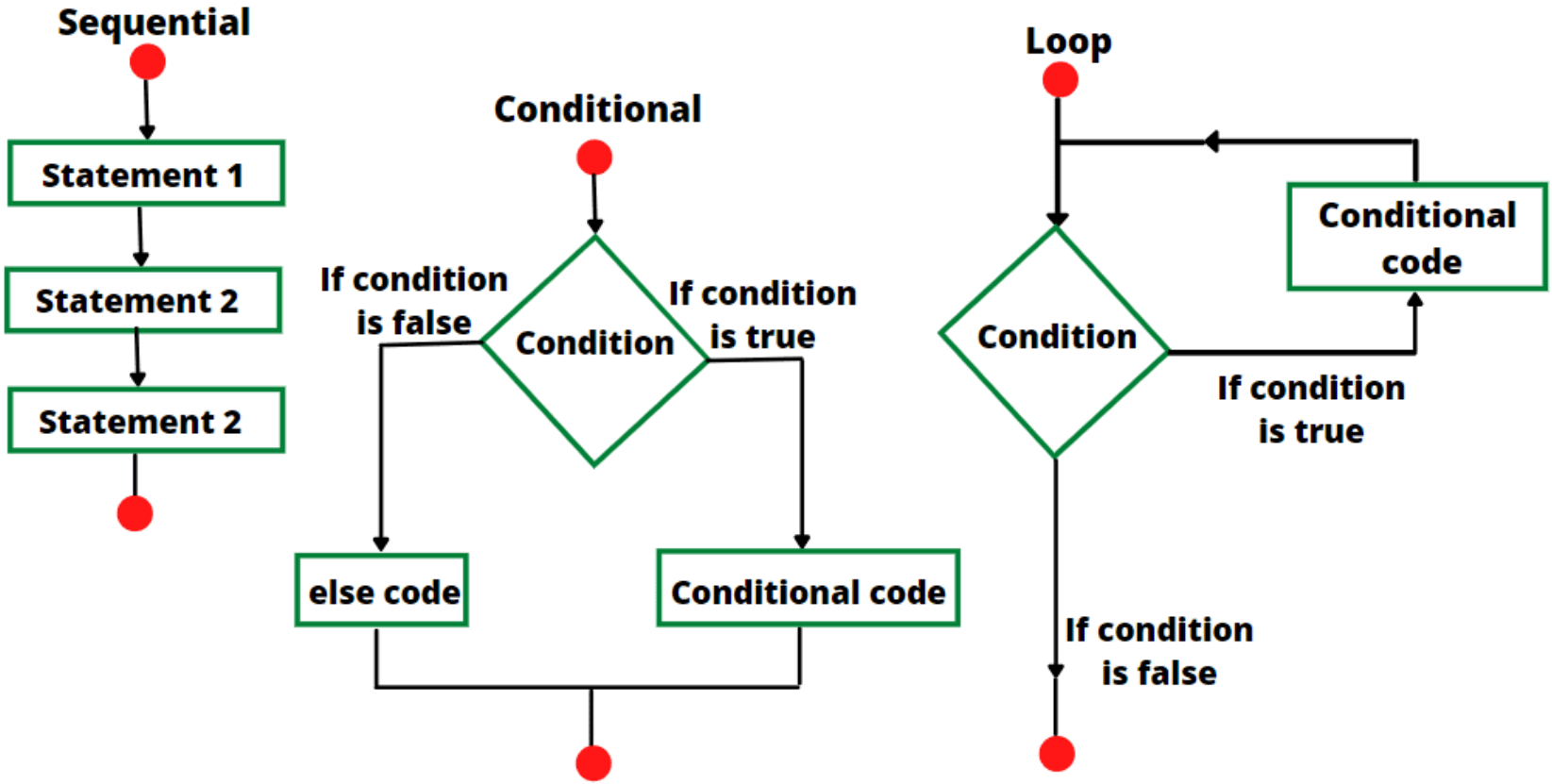


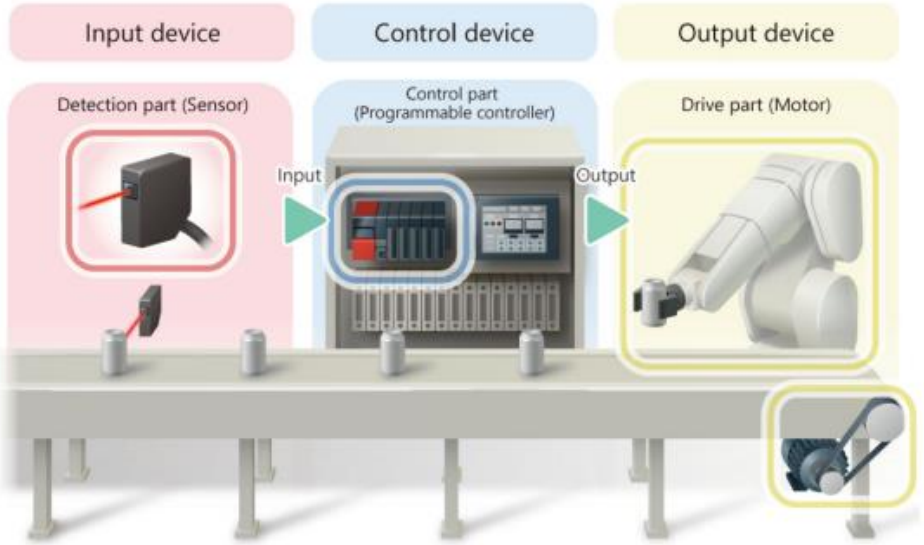
Fig: Three main types of control flow in computer program

The same operation can be repeated correctly and automatically for any number of times by using sequence control.

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1.4 Devices Required for Sequence Control

In this section, let's learn how sequence control work. The following devices are required for sequence control.

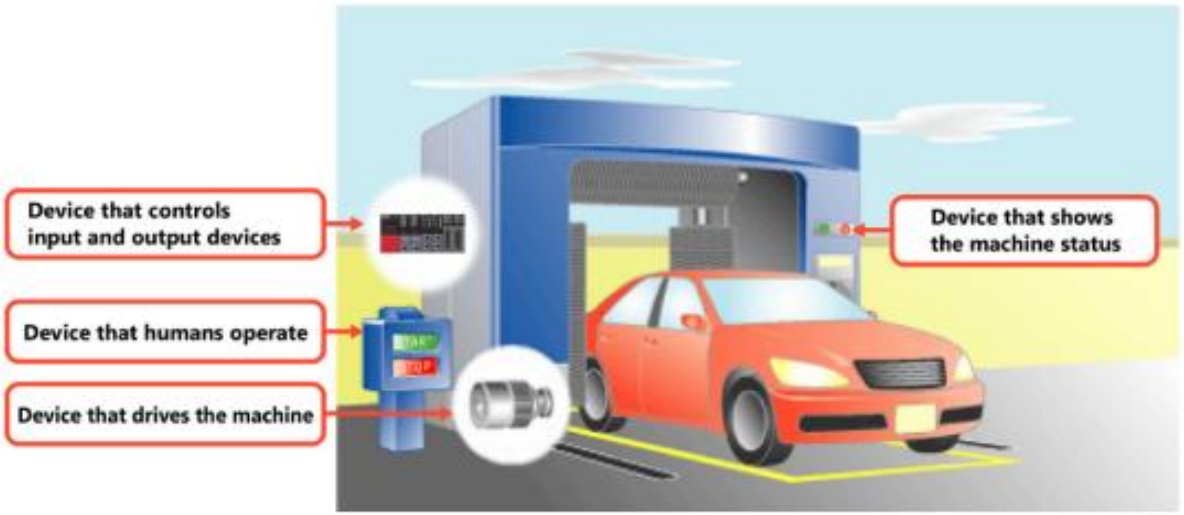


Device	Description
Input device	Device that humans operate (such as a start switch and a stop switch) Device that detects the machine status (such as a sensor and a proximity switch)
Control device	Device that controls input devices and output devices, and sends commands to drive a machine (such as a programmable controller)
Output device	Device that drives a machine (such as a motor and a solenoid valve) Device that shows the machine status (such as an indicator lamp and a warning buzzer)

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1.4 Devices Required for Sequence Control

Now, let's take a look at specific examples of devices required for sequence control in a car-washing machine.



Device	Type of control	Device used (Example)
Input device	Device that detects the machine status	A proximity switch that detects a car approaching to the machine
	Device that humans operate	A start button to start car-washing, a stop button to stop car-washing
Control device	Device that controls input devices and output devices, and sends commands to drive a machine	A programmable controller that controls the machine
Output device	Device that shows the machine status	Lamps that show the machine status during car-washing
	Device that drives the machine	Pumps that supply cleaning solution and water, a motor to rotate brushes

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1.5 Basic Sequence Control (Sequential Control)

Basic sequence control is achieved by integrating the following controls into the operation of a machine.

• Sequential control • Conditional control • Time limit control • Counting control

(1) Sequential control

The operation of the machine is performed from one step to another according to a predetermined sequence. This type of control is called "sequential control". In the example of the car-washing machine, the same operation is automatically repeated for any number of times according to the predetermined sequence.

Click the [Play] button to start the video.



As shown in the sequential control example above, a series of operations are performed one step to another according to a predetermined sequence.



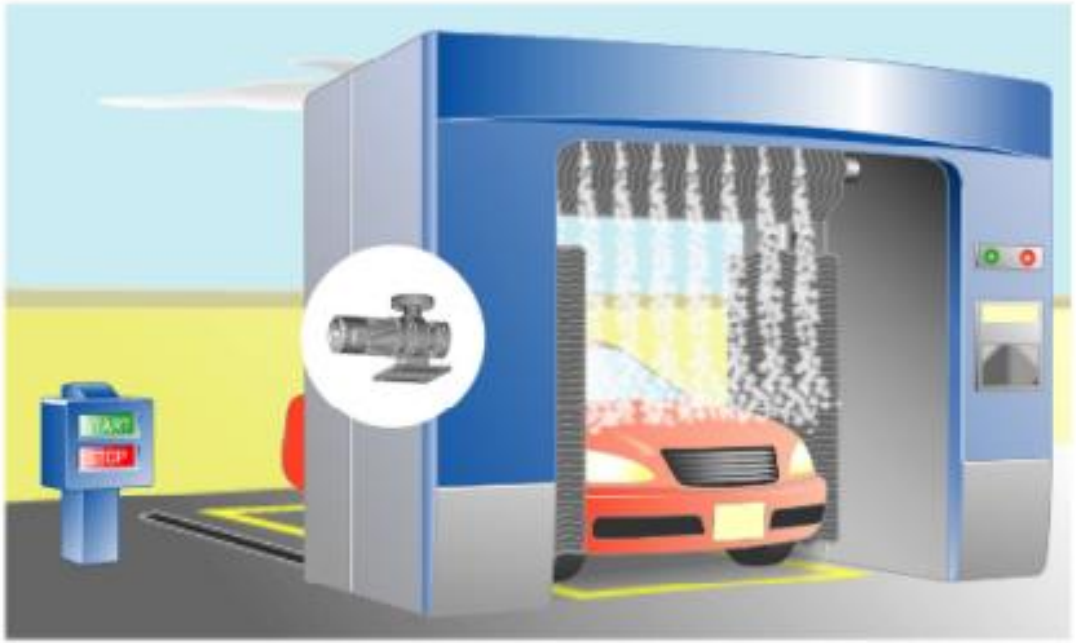
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1.5 Basic Sequence Control (Conditional Control)

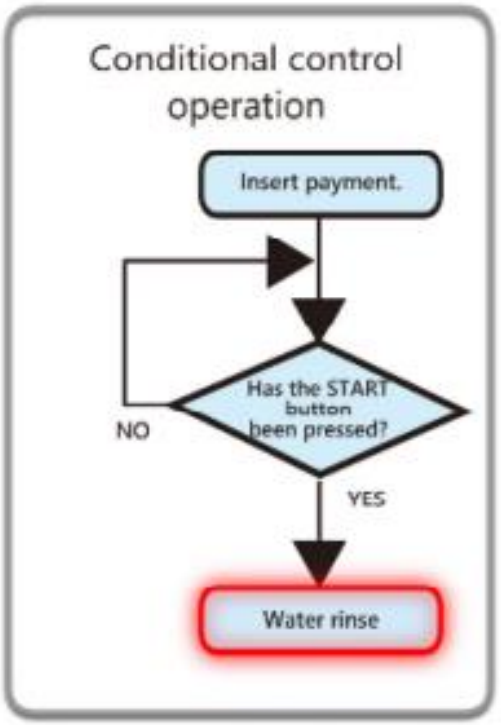
(2) Conditional control

The operation commands to the control target are determined by a condition. This type of control is called "conditional control". In the example of the car-washing machine, car-washing starts only after payment is inserted.

Click the [Play] button to start the video.



As shown in the conditional control example above, the operation is performed based on a condition.



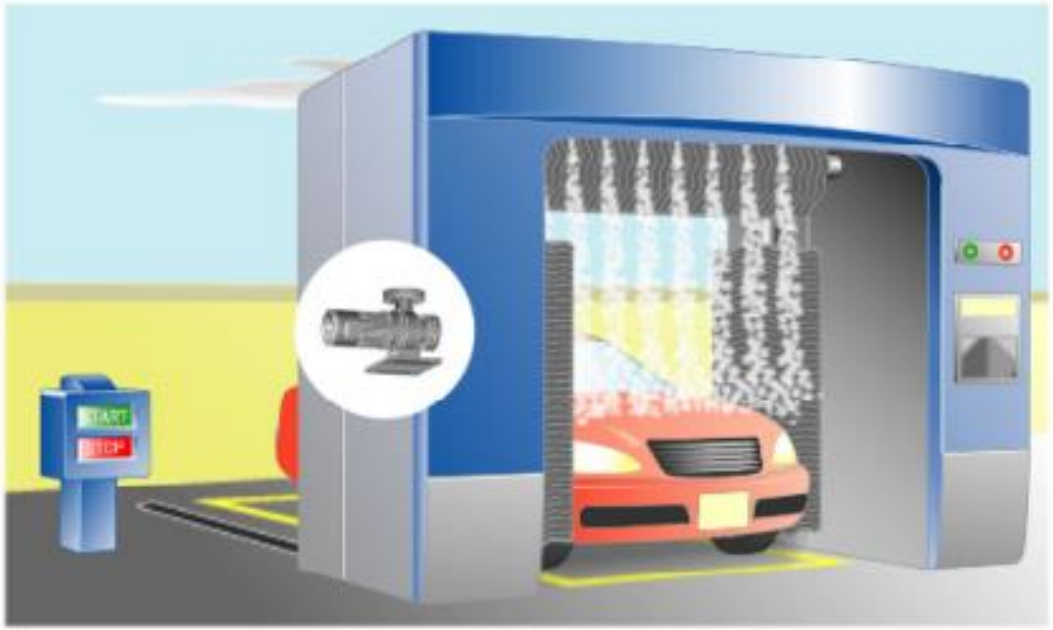
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1.5 Basic Sequence Control (Time Limit Control)

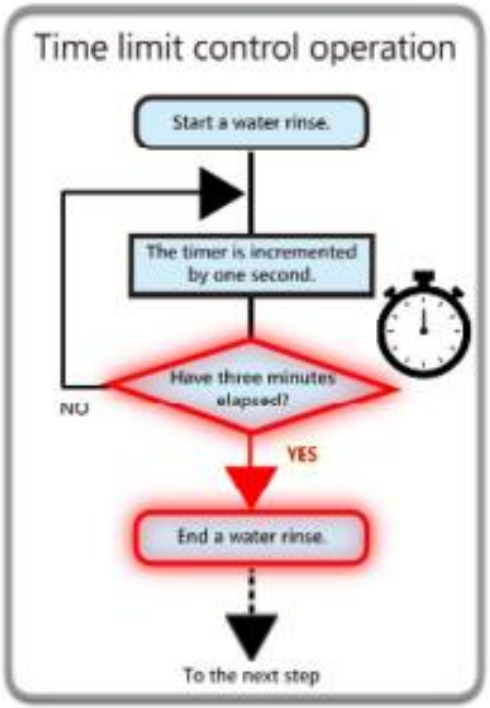
(3) Time limit control

The operation commands to the control target are determined by a preset time and timing. This type of control is called "time limit control".
The timer function is required for time limit control.

Click the [Play] button to start the video.



As shown in the time limit control example above, the currently running control switches to next control after the set period of time has elapsed.



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1.5 Basic Sequence Control (Counting Control)

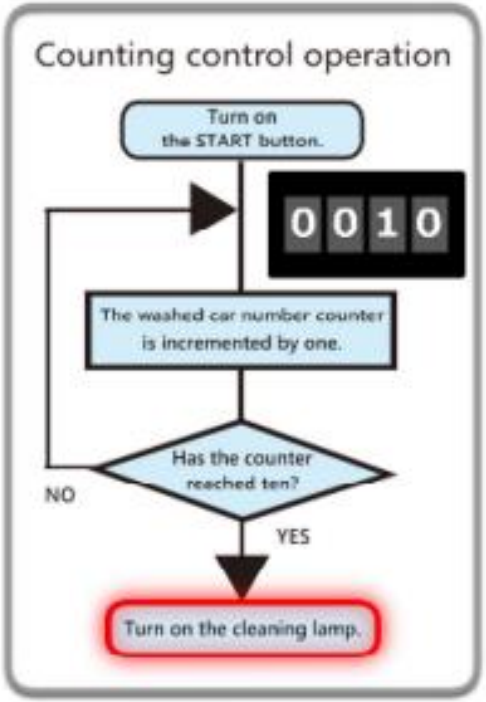
(4) Counting control

The operation commands to the control target are determined by a count, such as the number of products and the number of machine operations. This type of control is called "counting control".
The counter function is required for counting control.

Click the [Play] button to start the video.



In the counting control example above, after ten cars are washed, a cleaning lamp turns on and the cleaning process starts.



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Chapter 2 What is a "Programmable Controller"?

In Chapter 1, you have learned about sequence control.

In this chapter, let's learn about programmable controllers.

2.1 History

2.2 Relays

2.3 Differences Between Relay Control and Sequence Control

2.4 Features of Programmable Controllers and Personal Computers

2.5 Structure of Programmable Controllers

2.6 Basic Knowledge of Contacts

2.7. Operation of Programmable Controllers

2.8 Programs

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2.1 History

Sequence control using contact relays was dominant in the 1960s. However, this type of sequence control was extremely time-consuming. Making a change in the control circuits whenever the device, equipment, or production system was replaced or updated was very complicated.

Meanwhile, the requirements for a new sequence control system to replace the one using contact relays were presented by an automobile manufacturer in the United States. As a result, the first programmable controller was developed as a controller that satisfies those requirements.

1969

The first programmable controllers were introduced to the market by seven manufacturers in the United States.



1970 to 1976

The first programmable controllers manufactured in Japan were introduced.
The first general-purpose programmable controllers appeared.



1977 to 1981

Mitsubishi Electric released their first general-purpose programmable controllers.
With the successful sales of MELSEC-K series and MELSEC-F series programmable controllers, Mitsubishi Electric established its current position in the market.

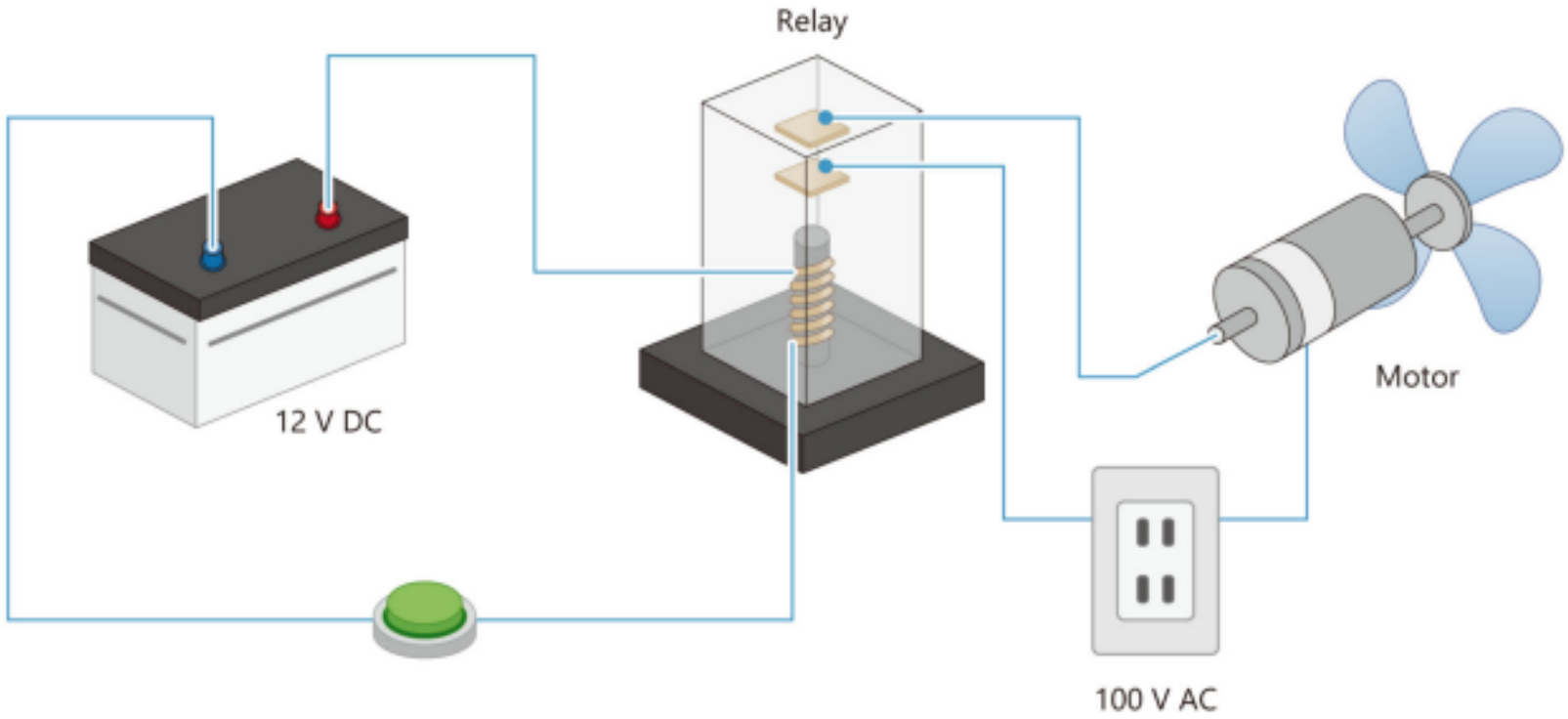


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2.2 Relays

A relay is an electrical switch operated by a relatively small signal that can turn on or off a much larger electric current. Each relay has an electromagnet internally. When electricity flows in the input circuit, it activates the electromagnet. The energized electromagnet closes the contact, allowing a bigger current to flow through the output circuit.

The following is an electrical schematic diagram example. A large motor can be controlled with the on/off signals.

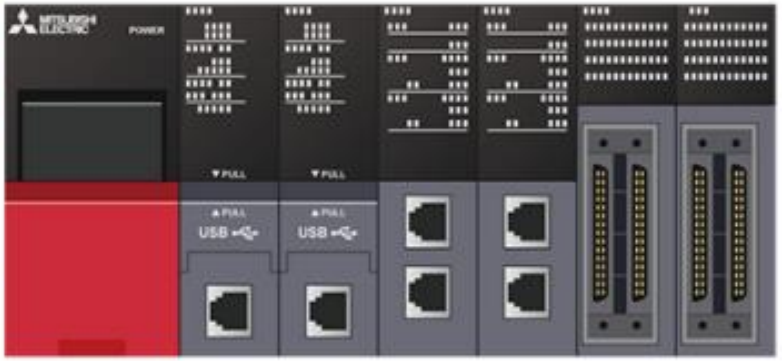


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2.3 Differences Between Relay Control and Sequence Control

In this section, let's learn about the differences between the relay control and the sequence control.





Relay control	Sequence control
Only on/off control can be performed.	On/off control and complex control can be performed.
The frequency of failure or breakdown is high and maintenance is not easy.	Reliability is high and maintenance is easy.
Circuits are modified by changing wiring.	Circuits are flexibly modified by using programs.
For large-scale systems, large space and long design period are required.	Even for large-scale systems, large space and long design period are not required, offering flexibility and extendibility.
Identifying the cause of a failure or an error and replacing the failed device are not easy.	All failures and errors can be monitored. The failed device can be replaced easily.

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2.4 Features of Programmable Controllers and Personal Computers

Both a programmable controller and a personal computer are required to perform complex control. However, they are used for different purposes.

High reliability

Environmental resistance

Real time reaction



Programmable controllers perform sequence control.

Language suitable for control field

Expandability

Multitasking

Full-color image

Complex operation



Personal computers perform information processing.

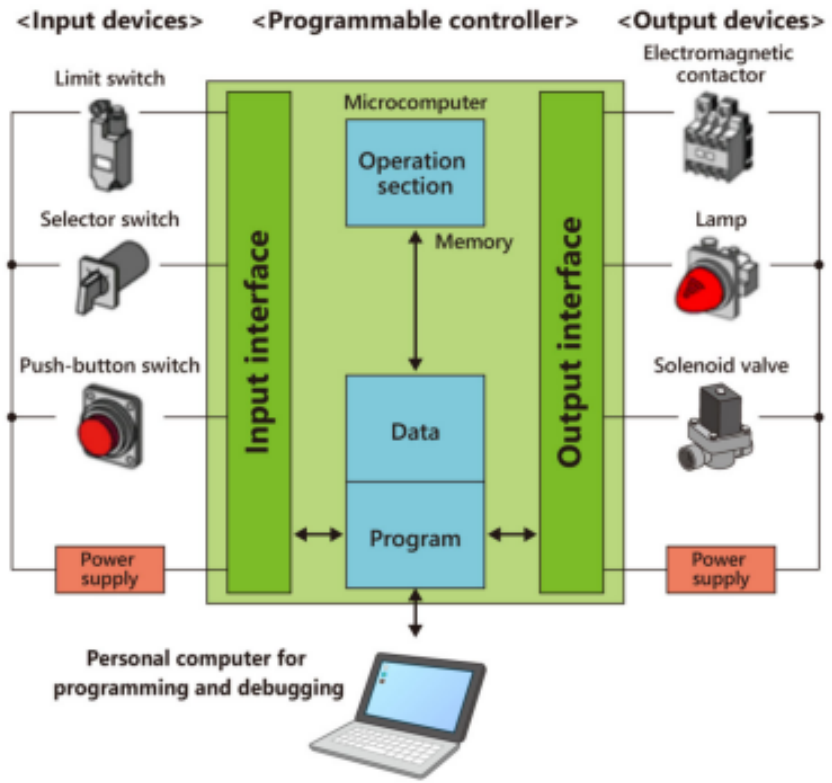
High-level language

File processing

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2.5 Structure of Programmable Controllers

Devices connected to the input side of the programmable controller are "input devices", and devices connected to the output side of the programmable controller are "output devices".
These devices are physically connected to the input/output interfaces of the programmable controller via wires.
The on/off (operation start/stop) signal of which input device is connected to which output device is determined by a program.
Programs are created using the engineering tool and written to the programmable controller (or, more precisely to the CPU module).



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2.6 Basic Knowledge of Contacts

Let's learn about contacts, which are frequently used in sequence control.

The role of a contact is to turn a relay or switch on and off (to allow or block the flow of electricity). A contact is, for example, used in a power switch.

(1) Normally open contact
This is a contact that is open in its default position. When actuated, it will close and electricity will flow.
Example: Start button



(2) Normally closed contact
This is a contact that is closed in its default position. When actuated, it will open and no electricity will flow.
Example: Emergency stop button



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2.6 Basic Knowledge of Contacts





Normally open contact

Normally closed contact

Actual contact



Actual contact



Ladder symbol



Ladder symbol



Ladder diagram



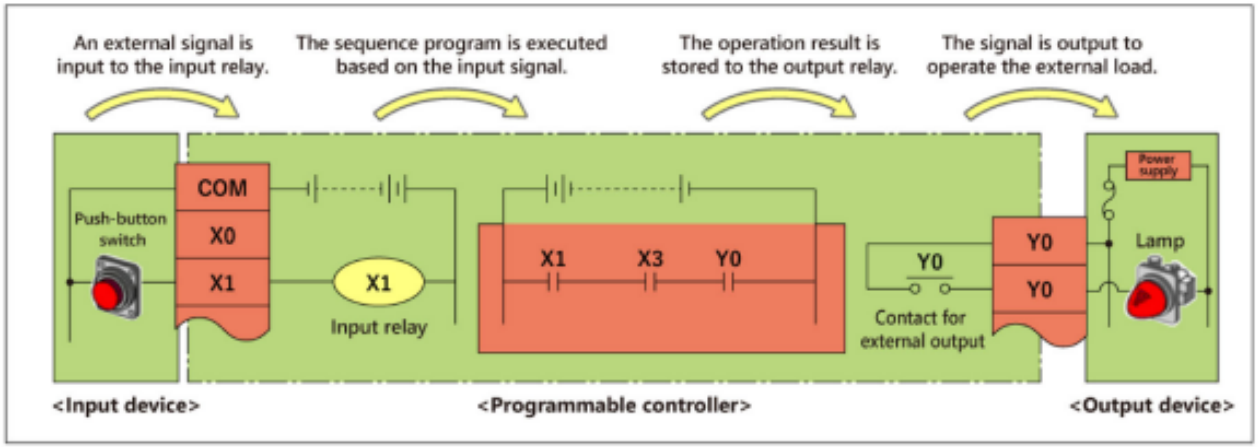
Ladder diagram



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2.7 Operation of Programmable Controllers

The following is the flow of signals used for operation.



The state of the input device is taken into the input relay of the programmable controller as an electrical on/off signal. The programmable controller executes the program using the input signal received and outputs the operation result (electrical on/off signal) to the output device through a contact for external output.

The following are the typical devices in the programmable controller.
Each device is described with a symbol and a number.

Device number		Description
Input	X0 ...	This is an area for receiving signals from input devices connected. The symbol is X. The device is also called "input relay".
Output	Y0 ...	This is an area for storing signals output to output devices connected. The symbol is Y. The device is also called "output relay".

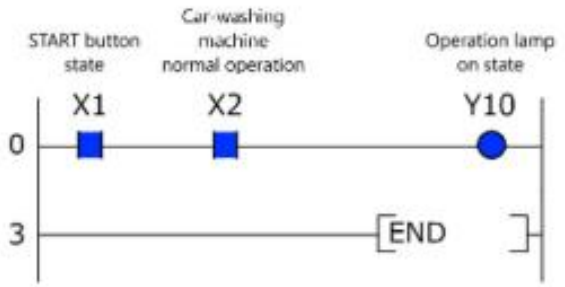
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2.8 Programs

Inside a programmable controller, sequence control is performed based on programs, such as the one shown below.
The following program is written using the ladder diagram language. This language is called "ladder" diagrams because they resemble a ladder.

◆ **Program that turns on the lamp**

Click the [Play] button to start the video.





Each instruction operation unit in the program is called a "step", and a number, which is called a "step number", is assigned to each step.
The CPU module executes instructions sequentially starting from step number 0. Once after the END instruction is executed, the program operation is returned to step number 0 and repeated again. This is called "cyclic operation". The time required to perform one sequence cycle is called "scan time".

As shown in the above program example, when two switches, X1 and X2, are connected in series, an "AND" operation is performed.
The AND instruction is one of the most basic sequence instructions.

END OF CHAPTER 2

Dr. Yılmaz KALKAN